

# **May 1993**

## **Preliminary Data Summary**

by      Field Research Facility

U.S. Army Corps of Engineers  
Waterways Experiment Station  
Coastal Engineering Research Center  
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## Preface

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This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

# 1 Introduction

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The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511.

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 7. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

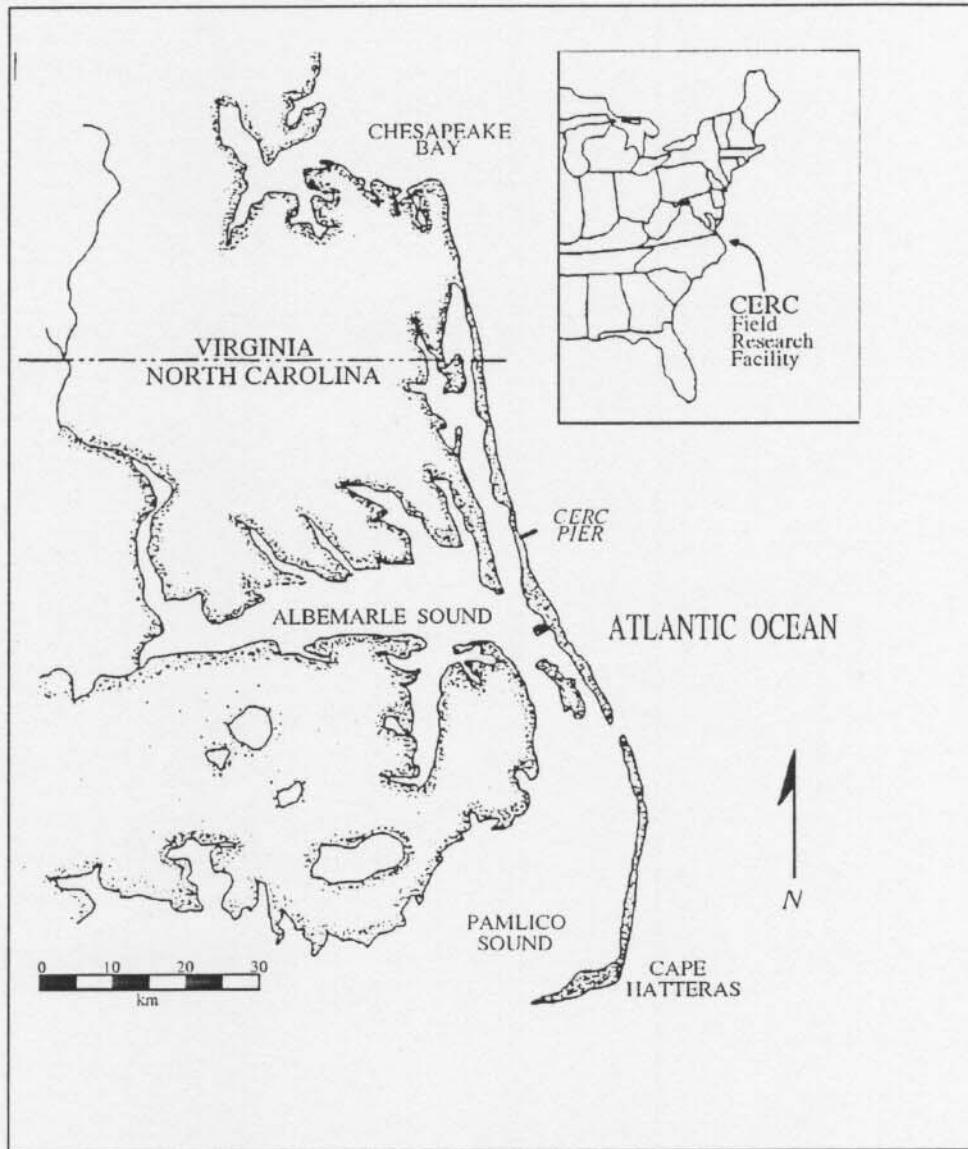


Figure 1. FRF Location Map

**Table 1**  
**Instrument Status/Data Availability**

Gauge Status \* = Operational / = Partial - = Non-Operational  
Data Collected \* = All / = Partial - = None  
Visual Observations \* = Complete / = Partial - = None

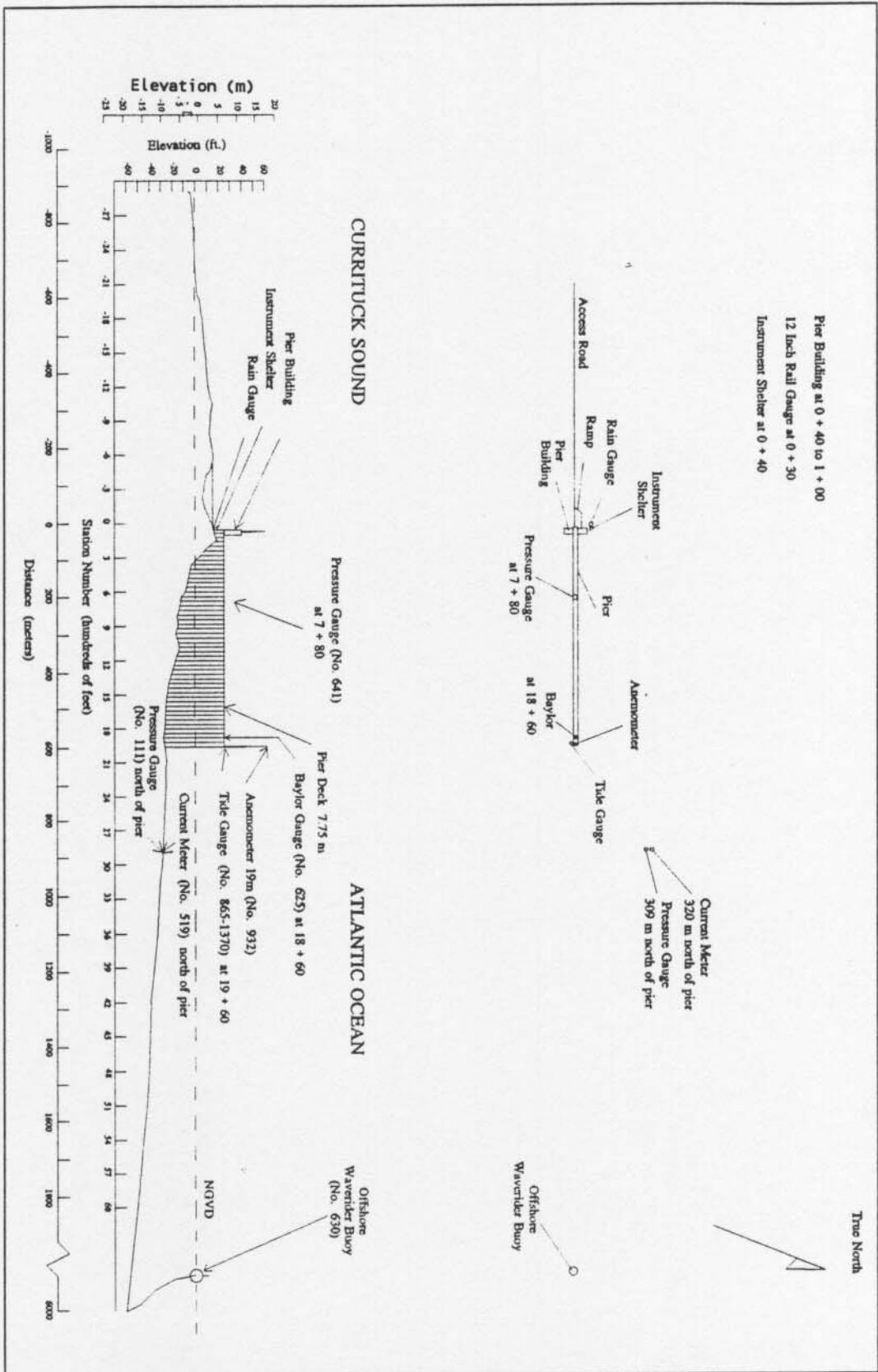


Figure 2. Instrument Locations. (Elevations from NGVD)

## 2 Meteorological Data

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A variety of instruments have been installed at the FRF (Figure 2) to monitor the meteorological conditions. The data presented in Table 2 are collected and stored using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m (Figure 2) using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions are determined by vector averaging the data. Wind directions indicate where the wind is coming from. Temperature and atmospheric pressure means are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 2 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -  
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -  
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -  
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -  
 $m/s \times 1.943 = kn$

**Table 2**  
**Meteorological Data**

May 1993

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	0		10.3	1017.3	0
	700	1	68	13.2	1019.2	0
	1300	5	83	15.4	1019.2	0
	1900	2	131	14.0	1019.2	0
2	100	1	161	13.6	1018.8	0
	700	2	111	15.3	1020.5	0
	1300	6	125	18.8	1021.2	0
	1900	3	132	14.6	1021.7	0
3	100	3	121	13.3	1021.9	0
	700	3	105	15.7	1023.8	0
	1300	5	89	16.2	1023.8	0
	1900	3	95	15.0	1022.3	0
4	100	2	124	14.1	1021.0	0
	700	2	109	14.5	1021.3	0
	1300	3	126	19.8	1021.0	0
	1900	5	146	16.4	1019.5	0
5	100	3	166	17.7	1019.3	0
	700	5	146	16.7	1020.5	0
	1300	4	160	22.3	1019.2	0
	1900	4	147	15.6	1017.8	12
6	100	4	196	19.6	1017.5	0
	700	3	254	19.9	1016.7	0
	1300	3	129	21.4	1016.0	0
	1900	3	148	18.1	1014.9	0
7	100	2	231	18.8	1015.5	0
	700	2	265	20.8	1015.6	0
	1300	3	123	22.4	1016.1	0
	1900	5	48	17.9	1017.4	0
8	100	3	50	15.9	1018.7	0
	700	3	68	17.4	1020.6	0
	1300	5	58	17.9	1022.7	0
	1900	4	84	15.9	1021.4	0
9	100	2	113	14.4	1021.4	0
	700	3	89	15.2	1022.1	0
	1300	4	120	20.5	1021.6	0
	1900	4	140	17.4	1020.0	0
10	100	2	179	16.7	1019.3	0
	700	2	141	18.0	1020.0	0
	1300	5	118	22.2	1019.5	0
	1900	4	152	18.6	1019.2	0

**Table 2**  
**Meteorological Data (continued)**

May 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	4	198	19.8	1018.3	0
	700	4	207	21.5	1017.4	0
	1300	4	223	27.7	1014.0	0
	1900	6	204	24.3	1009.9	0
	100	7	236	22.2	1007.9	0
12	700	8	242	21.5	1007.2	0
	1300	4	242	27.3	1005.7	0
	1900	7	208	25.2	1002.8	0
	100	5	238	21.4	1004.4	0
13	700	7	237	21.4	1003.8	0
	1300	5	233	25.1	1002.7	0
	1900	5	200	20.7	1002.1	0
	100	5	230	19.6	1002.4	0
14	700	5	1	14.3	1004.1	0
	1300	7	21	16.7	1006.3	0
	1900	2	16	15.2	1007.6	0
	100	0		12.0	1008.7	0
15	700	2	211	18.9	1011.2	0
	1300	5	142	21.9	1011.4	0
	1900	6	185	20.4	1010.8	0
	100	6	219	19.4	1011.9	0
16	700	6	229	21.2	1012.5	0
	1300	4	217	28.2	1011.0	0
	1900	5	190	23.4	1009.7	0
	100	4	55	15.3	1010.5	0
17	700	4	254	21.7	1011.2	0
	1300	6	23	20.6	1011.8	0
	1900	5	80	17.0	1012.0	0
	100	4	88	17.4	1011.2	0
18	700	5	196	22.3	1009.8	0
	1300	8	202	27.4	1007.6	0
	1900	5	146		1006.4	6
	100	3	241		1005.3	0
19	700	5	150	Gauge	1005.7	12
	1300	2	286		1003.6	0
	1900	3	143		1003.6	14
	100	1	269	Inoperative	1002.1	0
20	700	5	3		1003.4	0
	1300	4	352		1004.8	0
	1900	4	28		1006.3	0

**Table 2**  
**Meteorological Data (concluded)**

May 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	4	27	1007.5	0	
	700	4	45	1009.7	0	
	1300	5	31	1010.9	0	
	1900	4	74	1010.9	0	
22	100	0		1011.6	0	
	700	6	307	Gauge	1012.7	0
	1300	3	355		1014.2	0
	1900	3	274		1014.9	0
23	100	3	280		1016.6	0
	700	5	295		1018.5	0
	1300	2	79	Inoperative	1018.8	0
	1900	6	147		1017.2	0
24	100	6	228		1017.0	0
	700	6	233		1018.4	0
	1300	5	211		1017.0	0
	1900	6	185		1016.3	0
25	100	8	220		1016.7	0
	700	7	238		1018.6	0
	1300	6	219		1016.6	0
	1900	6	201	23.9	1015.9	0
26	100	6	226	20.6	1016.5	0
	700	5	258	20.7	1016.9	0
	1300	4	7	13.8	1017.7	0
	1900	0		15.7	1018.3	0
27	100	4	287	16.1	1018.9	0
	700	4	284	16.9	1020.5	0
	1300	1	51	25.6	1020.4	0
	1900	3	159	20.0	1019.6	0
28	100	4	223	19.9	1019.9	0
	700	6	242	20.8	1020.9	0
	1300	5	216	27.8	1018.6	0
	1900	6	195	23.3	1016.8	0
29	100	7	237	21.3	1015.7	0
	700	7	1	22.5	1014.5	0
	1300	4	231	28.9	1012.8	0
	1900	6	61	18.5	1014.1	0
30	100			17.4	1015.7	0
	700		Gauge	18.1	1017.9	0
	1300			18.7	1017.6	0
	1900		Inoperative	16.5	1015.6	0
31	100			16.4	1013.9	0
	700	4	139	18.8	1012.2	0
	1300	5	164	26.6	1009.1	0
	1900	4	1	20.0	1006.9	4
Resultant				Mean	Mean	Total
	2		186	19.2	1014.5	48

### 3 Wave Data

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Wave data are collected from a Baylor staff gauge (Gauge 625), two pressure wave gauges (641 and 511) and a Waverider buoy (Gauge 630) as shown in Table 1 and Figure 2. The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAX 11/750 programmed to sample the gauges for two hour and forty-eight minute time frames. The sampling rate is two times per second which equals five contiguous 34 minute records per collection period. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record.

Wave height  $H_{mo}$  is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 deg of freedom calculated from a 34-min record. Peak wave period  $T_p$  is defined as the period associated with the maximum energy in the spectrum. When this analysis is complete, the data are written to optical disc.

Table 3 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 3 are average values computed from this data. Figure 3 is a time history of all  $H_{mo}$  and  $T_p$  values obtained for all gauges.

Differences in wave periods between wave gauges (Table 3 and Figure 3) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 3**  
**Wave Data**

May 1993											
Day	Hour	641		625		Baylor 1860		511		630	
		Pressure Gauge	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Pressure Gauge	Hmo,m	Tp,sec	Waverider	Hmo,m
1	0100	0.72	11.64	1.47	10.67	1.60	11.13	1.59	10.67		
	0700	0.54	11.64	1.21	10.67	1.37	10.67	1.30	9.14		
	1300	0.60	9.85	1.24	10.24	1.33	10.24	1.28	9.14		
	1900	0.38	10.24	0.98	9.85	1.06	9.14	1.11	9.85		
2	0100	0.41	9.14	0.96	8.83	1.01	9.85	1.07	9.48		
	0700	0.29	9.85	0.77	10.24	0.86	10.67	0.95	10.24		
	1300	0.34	9.85	0.86	9.85	0.96	8.83	1.03	8.83		
	1900	0.26	9.48	0.72	9.48	0.71	9.14	0.79	8.83		
3	0100	0.26	8.26	0.69	9.14	0.73	8.83	0.82	8.53		
	0700	0.27	9.85	0.61	9.48	0.68	9.48	0.68	8.83		
	1300	0.36	2.81	0.73	9.14	0.68	8.00	0.86	8.53		
	1900	0.41	4.74	0.72	8.26	0.72	9.14	0.88	9.14		
4	0100	0.34	5.33	0.77	8.26	0.81	9.14	0.92	9.14		
	0700	0.47	5.45	0.86	6.40	0.92	8.53	0.99	8.53		
	1300	0.37	5.33	0.86	9.14	0.84	8.26	0.95	8.00		
	1900	0.47	9.48	0.88	9.85	0.86	8.53	0.99	8.53		
5	0100	0.34	4.92	0.83	9.14	0.97	9.14	1.02	9.85		
	0700	0.42	9.14	0.86	9.48	0.91	9.85	1.02	9.48		
	1300	0.31	4.83	0.76	8.83	0.76	9.48	0.87	9.85		
	1900	0.40	9.48	0.72	9.85	0.72	9.14	0.86	9.14		
6	0100	0.25	4.83	0.59	8.83	0.67	9.14	0.77	9.48		
	0700	0.33	5.22	0.63	9.85	0.72	8.83	0.76	8.26		
	1300	0.21	4.49	0.53	8.83	0.61	9.14	0.61	9.48		
	1900	0.28	9.14	0.53	8.53	0.58	8.53	0.62	8.83		
7	0100	0.16	9.85	0.40	9.14	0.49	8.53	0.50	8.83		
	0700	0.21	5.12	0.41	8.00	0.44	8.26	0.49	9.48		
	1300	0.15	12.19	0.38	8.26	0.40	8.53	0.43	8.00		
	1900	0.22	4.92	0.40	8.53	0.41	8.26	0.46	12.80		
8	0100	0.32	3.94	0.49	7.76	0.52	7.76	0.64	8.00		
	0700	0.34	3.71	0.59	7.53	0.57	8.53	0.65	7.76		
	1300	0.30	3.20	0.57	7.31	0.59	8.00	0.72	7.11		
	1900	0.41	4.34	0.73	7.53	0.69	7.31	0.84	7.11		
9	0100	0.32	7.53	0.67	7.11	0.62	8.00	0.73	8.53		
	0700	0.30	7.53	0.71	5.69	0.71	5.95	0.78	7.31		
	1300	0.27	7.76	0.74	8.00	0.78	8.53	0.87	8.26		
	1900	0.29	8.00	0.68	7.76	0.73	7.76	0.82	7.76		
10	0100	0.25	16.00	0.57	8.83	0.66	8.26	0.69	7.11		
	0700	0.26	8.53	0.66	8.53	0.69	8.53	0.73	8.53		
	1300	0.25	8.00	0.55	8.26	0.64	9.14	0.64	8.53		
	1900	0.24	9.14	0.58	9.14	0.60	9.14	0.62	8.53		

**Table 3**  
**Wave Data (continued)**

May 1993									
Day	Hour	641		625		511		630	
		Pressure Gauge Hmo,m	Tp,sec	Baylor 1860 Hmo,m	Tp,sec	Pressure Gauge Hmo,m	Tp,sec	Waverider Hmo,m	Tp,sec
11	0100	0.26	9.48	0.56	9.85	0.58	10.24	0.63	9.48
	0700	0.20	9.48	0.55	9.48	0.63	9.85	0.60	10.24
	1300	0.23	9.85	0.54	9.85	0.59	10.24	0.62	10.24
	1900	0.24	9.85	0.50	9.14	0.50	9.48	0.63	9.85
12	0100	0.21	9.48	0.44	9.48	0.46	10.24	0.56	9.85
	0700	0.19	10.67	0.46	10.67	0.54	10.67	0.56	11.64
	1300	0.24	10.67	0.47	10.67	0.52	10.67	0.50	10.67
	1900	0.22	10.24	0.37	9.85	0.43	11.13	0.49	11.13
13	0100	0.24	5.82	0.36	10.67	0.37	10.67	0.48	9.85
	0700	0.19	5.12	0.31	10.67	0.32	9.85	0.48	9.85
	1300	0.26	5.82	0.35	10.67	0.39	10.67	0.47	6.09
	1900	0.19	4.92	0.31	10.67	0.34	10.67	0.42	9.85
14	0100	0.25	5.57	0.34	11.13	0.37	11.13	0.47	5.95
	0700	0.40	3.46	0.59	3.56	0.55	3.28	0.64	3.20
	1300	0.82	4.74	0.95	4.41	0.95	4.41	1.07	4.92
	1900	0.39	4.66	0.62	4.83	0.60	4.83	0.71	5.02
15	0100	0.34	4.41	0.52	4.34	0.54	9.48	0.59	4.57
	0700	0.24	6.24	0.47	9.14	0.48	6.56	0.52	9.85
	1300	0.28	6.74	0.56	6.24	0.54	6.74	0.69	6.40
	1900	0.26	3.94	0.49	13.47	0.49	14.22	0.67	13.47
16	0100	0.21	12.80	0.41	12.80	0.48	13.47	0.53	12.80
	0700	0.18	12.80	0.41	12.19	0.46	12.80	0.48	12.19
	1300	0.22	12.19	0.42	12.19	0.48	11.64	0.47	11.64
	1900	0.21	12.19	0.41	12.19	0.44	12.19	0.50	7.11
17	0100	0.17	12.80	0.38	12.19	0.43	12.19	0.45	12.19
	0700	0.30	3.61	0.49	12.19	0.50	12.19	0.59	11.64
	1300	0.25	11.64	0.43	11.64	0.47	11.64	0.52	11.64
	1900	0.34	3.16	0.53	11.64	0.48	11.13	0.66	3.33
18	0100	0.28	3.71	0.49	10.67	0.46	11.13	0.57	10.67
	0700	0.27	4.20	0.45	11.13	0.44	10.24	0.52	10.67
	1300	0.29	4.00	0.50	3.71	0.45	10.67	0.64	3.94
	1900	0.25	5.12	0.38	10.67	0.38	10.67	0.49	11.13
19	0100	0.26	4.92	0.45	10.67	0.43	10.24	0.52	10.24
	0700	0.34	6.09	0.56	10.67	0.50	11.13	0.62	11.13
	1300	0.25	11.13	0.43	11.64	0.48	10.67	0.53	11.13
	1900	0.25	5.95	0.43	10.24	0.43	11.13	0.50	11.13
20	0100	0.24	5.69	0.45	10.67	0.50	11.13	0.54	11.13
	0700	0.38	6.24	0.55	6.40	0.60	6.74	0.73	6.24
	1300	0.46	4.27	0.68	4.06	0.79	4.34	0.94	4.27
	1900	0.52	4.49	0.66	4.27	0.75	4.34	0.91	4.20

**Table 3**  
**Wave Data (concluded)**

May 1993									
Day	Hour	641		625		511		630	
		Pressure Gauge	Baylor 1860	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec
21	0100	0.37	4.27	0.63	4.41	0.69	12.19	0.91	4.49
	0700	0.32	16.00	0.54	11.64	0.61	17.07	0.63	16.00
	1300	0.34	17.07	0.60	17.07	0.62	17.07	0.70	11.64
	1900	0.36	17.07	0.67	16.00	0.59	11.64	0.68	17.07
22	0100	0.23	16.00	0.51	16.00	0.54	16.00	0.56	16.00
	0700	0.26	13.47	0.52	13.47	0.46	14.22	0.60	7.53
	1300	0.35	3.33	0.65	13.47	0.64	14.22	0.79	3.46
	1900	0.25	13.47	0.46	14.22	0.46	14.22	0.49	13.47
23	0100	0.18	13.47	0.42	13.47	0.46	13.47	0.45	13.47
	0700	0.20	13.47	0.41	12.80	0.40	15.06	0.45	12.80
	1300	0.16	16.00	0.33	15.06	0.37	16.00	0.34	14.22
	1900	0.25	14.22	0.54	15.06	0.42	15.06	0.57	3.46
24	0100	0.15	15.06	0.36	14.22	0.39	15.06	0.45	14.22
	0700	0.16	14.22	0.35	14.22	0.40	13.47	0.46	9.48
	1300	0.16	10.24	0.38	9.85	0.42	10.24	0.45	9.85
	1900	0.22	10.24	0.43	9.85	0.49	9.85	0.57	10.24
25	0100	0.17	10.24	0.42	9.85	0.53	10.24	0.53	10.24
	0700	0.17	9.48	0.42	9.48	0.47	9.85	0.48	9.85
	1300	0.17	9.85	0.42	9.48	0.53	9.48	0.50	9.48
	1900	0.21	9.14	0.42	9.48	0.46	9.48	0.47	9.85
26	0100	0.21	9.48	0.44	9.48	0.52	9.48	0.58	9.48
	0700	0.18	9.14	0.41	9.14	0.52	9.48	0.58	9.48
	1300	0.60	4.41	0.89	4.41	0.79	9.48	1.06	4.49
	1900	0.37	4.57	0.57	9.14	0.59	9.14	0.75	9.14
27	0100	0.25	9.48	0.48	9.48	0.50	9.14	0.57	9.14
	0700	0.16	9.48	0.41	9.14	0.50	8.83	0.53	9.14
	1300	0.17	9.14	0.43	9.14	0.47	9.48	0.56	9.14
	1900	0.17	9.14	0.39	8.83	0.48	9.14	0.56	9.14
28	0100	0.25	9.48	0.44	9.85	0.50	9.14	0.52	9.14
	0700	0.19	8.83	0.47	9.14	0.51	9.14	0.61	9.14
	1300	0.25	9.85	0.43	9.14	0.46	8.83	0.48	8.83
	1900	0.21	9.14	0.41	9.14	0.43	9.14	0.56	9.14
29	0100	0.22	9.48	0.40	9.48	0.38	8.83	0.49	9.14
	0700	0.15	9.14	0.34	9.14	0.37	9.14	0.43	9.14
	1300	0.22	9.14	0.38	9.14	0.36	8.83	0.45	9.14
	1900	0.24	9.48	0.40	9.48	0.40	9.48	0.52	9.14
30	0100			0.68	8.83	0.57	8.53	0.72	3.61
	0700	Gauge		0.86	4.06	0.74	3.94	0.96	4.06
	1300			0.97	4.74	0.87	4.66	1.06	4.83
	1900	Inoperative		0.72	5.69	0.73	5.57	0.92	5.82
31	0100			0.73	9.14	0.65	8.53	0.80	5.82
	0700			0.55	9.48	0.53	8.53	0.61	9.48
	1300			0.56	9.14	0.51	8.26	0.67	9.14
	1900			0.44	8.83	0.45	8.83	0.56	8.53
Mean		0.29	8.42	0.57	9.54	0.59	9.80	0.67	9.06
Std dev		0.11	3.51	0.20	2.61	0.21	2.54	0.21	2.66

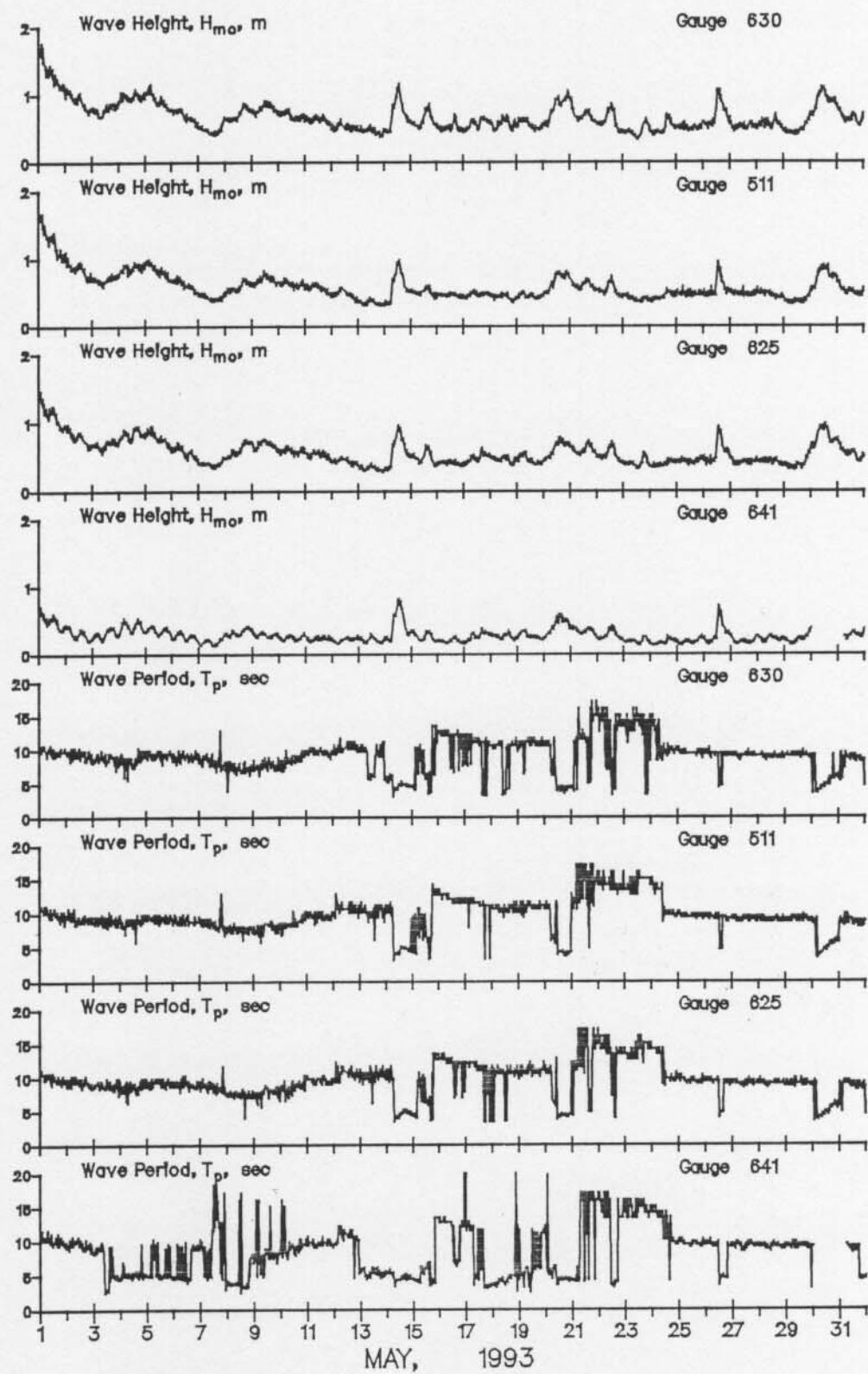


Figure 3. Time History of Wave Heights and Periods

## 4 Current Data

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Current data (Table 4) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of dye on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 5).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or off-shore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards.

### IMPORTANT NOTE

Direction resultants regarding the current meter data (gauge 519) may be in error by 5 degrees due to the uncertainty of the orientation. Please call us if you must use this data.

**Table 4**  
**Current Meter Data - Gauge 519**

MAY 1993

	Cross Long					Cross Long					Cross Long							
	Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir
1	100	0	-1	2	316		1300	7	9	11	138		22	100	1	3	3	164
	700	6	15	16	154		1900	-4	-2	6	297			700	3	-1	4	53
	1300	4	15	15	159	12	100	-3	-5	7	318			1300	9	35	37	160
	1900	8	16	18	150		700	-6	-5	9	305			1900	10	5	11	112
2	100	2	-6	7	9		1300	0	0	0			23	100	14	25	29	145
	700	3	2	4	124		1900	3	-1	4	43			700	2	18	18	169
	1300	-1	0	2	288	13	100	-1	2	3	219			1300	3	17	18	164
	1900	1	3	3	150		700	-2	1	3	245			1900	0	2	2	184
3	100	0	-8	9	348		1300	0	3	3	165		24	100	-3	-10	11	336
	700	2	-2	4	28		1900	0	-12	13	357			700	-4	-17	19	339
	1300	0	-2	3	340	14	100	-2	1	3	241			1300	-3	-22	23	345
	1900	3	8	9	153		700	15	17	23	135			1900	-1	-4	5	332
4	100	2	6	6	157		1300	16	23	28	140		25	100	-3	0	4	279
	700	9	18	20	149		1900	11	19	22	146			700	-7	-4	9	296
	1300	2	10	10	166	15	100	14	16	21	134			1300	-2	0	3	276
	1900	4	15	15	162		700	11	21	23	147			1900	0	-13	14	355
5	100	1	6	6	161		1300	0	16	16	180		26	100	-2	0	3	276
	700	4	5	6	137		1900	1	0	1	26			700	-2	0	3	279
	1300	0	4	4	182	16	100	-2	-5	7	325			1300	12	14	19	134
	1900	-1	-4	5	330		700	-2	-3	4	320			1900	15	16	22	132
6	100	0	-7	8	344		1300	0	-4	5	359		27	100	6	3	7	112
	700	0	-5	6	347		1900	-3	0	4	280			700	7	23	24	157
	1300	4	-1	4	58	17	100	0	-3	4	341			1300	6	22	23	159
	1900	0	-2	3	348		700	1	3	3	157			1900	6	11	12	146
7	100	1	0	2	44		1300	12	5	13	106		28	100	4	-3	6	39
	700	3	-3	5	28		1900	4	0	4	74			700	0	2	2	162
	1300	9	41	41	163	18	100	3	13	13	163			1300	1	1	2	146
	1900	4	13	14	159		700	1	16	16	172			1900	2	-3	4	25
8	100	8	35	36	162		1300	-3	3	4	230		29	100	-2	-3	5	315
	700	3	19	19	165		1900	1	5	5	167			700	-3	-1	4	291
	1300	12	43	45	159	19	100	-1	8	8	188			1300	0	1	1	182
	1900	5	17	18	157		700	4	9	10	150			1900	1	10	10	170
9	100	10	20	22	148		1300	-3	-7	9	330		30	100	0	1	1	201
	700	0	3	3	183		1900	1	7	8	164			700	4	12	13	156
	1300	4	8	9	151	20	100	8	3	8	107			1300	4	13	14	157
	1900	-1	-10	11	343		700	14	3	14	99			1900	12	38	40	157
10	100	1	-10	12	1		1300	16	24	29	141		31	100	2	4	4	144
	700	-2	-8	9	335		1900	3	15	15	165			700	1	0	1	20
	1300	1	0	1	32	21	100	12	43	45	159			1300	-2	-1	3	297
	1900	0	-5	6	347		700	13	31	34	152			1900	1	5	5	165
11	100	3	-3	4	31		1300	21	42	47	148							
	700	1	5	5	170		1900	0	11	11	174							

**KEY:**

- +crossshore = offshore, cm/sec
- crossshore = onshore, cm/sec
- +longshore = south, cm/sec
- longshore = north, cm/sec
- Speed = Resultant speed, cm/sec
- Dir = Resultant direction, degrees true north

**Table 5**  
**Visual Observed Current Data**

May 1993												
	Pier End				Mid-Surf Zone				Beach			
Day	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	0	0	0		29	-32	43	22	South	28	S	
2	-1	-12	13	334	17	-68	70	354	South	9	S	
3	0	-23	23	340	9	-47	48	351	South	3	N	
4	-3	14	14	174	6	-55	56	346	South	11	N	
5	-1	-3	3	321	3	-61	61	343	South	7	N	
6	2	-5	6	4	7	-17	19	2	South	3	N	
7	-10	17	20	191	0	0	0		North	5	N	
8	-10	68	68	169	0	-47	47	340	South	3	S	
9	0	0	0		2	-41	41	343	South	17	N	
10	3	-30	31	346	14	-55	57	354	South	8	N	
11	6	-18	20	359	9	-87	88	346	South	7	N	
12	18	-7	20	48	17	-68	70	354	South	0		
13	23	-10	25	46	9	-27	28	359	South	4	N	
14	-13	32	35	182	0	30	30	160	North	29	S	
15	6	55	56	154	12	-47	48	354	South	3	N	
16	6	-29	30	351	8	-55	56	349	South	6	N	
17	0	0	0		10	-29	31	359	South	1	S	
18	4	29	29	151	0	-3	3	340	South	5	N	
19	-1	-16	16	337	5	-19	20	354	South	14	N	
20	-6	12	13	187	10	8	13	109	North	3	N	
21	-4	76	76	163	-2	22	22	166	North	8	S	
22	0	61	61	160	3	34	34	154	North	14	S	
23	-3	68	68	163	-1	12	12	166	North	6	S	
24	27	-14	30	43	1	-23	23	343	South	0		
25	15	-17	23	22	-3	-32	32	334	South	5	N	
26	15	-7	17	44	11	-36	37	357	South	3	N	
27	3	61	61	157	2	-47	47	343	North	25	N	
28	14	-8	16	42	3	-51	51	343	South	9	N	
29	13	-6	14	43	12	-6	13	42	South	12	N	
30	-1	-10	10	337	0	0	0		North	6	S	
31	-2	-38	38	337	0	-55	55	340	South	15	N	

**KEY:**

+crossshore = offshore, cm/sec  
 -crossshore = onshore, cm/sec  
 +longshore = south, cm/sec  
 -longshore = north, cm/sec  
 Speed = Resultant speed, cm/sec  
 Dir = Resultant direction, degrees true north

## 5 Visual Observations

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Visual wave direction measurements (Table 6) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

**Table 6**  
**Visual Observations**

Day	Time	Wave Approach Angle at Pier End deg from True N		Radar Wave Angle deg from True N	Width of Surf Zone,m	Water Characteristics		
		Primary	Secondary			Temp.,C	Density g/cc	Secchi Vis.,m
1	0915	65			153	12.8	1.0188	1.2
2	0915	70			134	13.3	1.0185	1.5
3	0615	85	120	80	87	10.7	1.0225	0.9
4	0610	80			82	12.2	1.0224	1.5
5	0635	75	130		73	12.7	1.0214	1.5
6	0750	75			69	10.3	1.0237	2.1
7	0800	90	140		30	13.9	1.0230	3.0
8	1235	65		95	84	17.9	1.0154	1.8
9	0830	75			71	18.1	1.0163	2.1
10	0740	80			45	13.3	1.0209	2.1
11	0610	80			77	11.2	1.0236	1.2
12	0635	75			73	10.0	1.0241	0.6
13	0715	80	145		26	9.7	1.0247	1.2
14	0750	25			26	12.8	1.0233	2.1
15	0750	65			49	17.4	1.0180	2.1
16	1115	75	140		52	13.6	1.0230	1.5
17	0725	80	35		49	10.6	1.0243	1.8
18	0555	65	105		9	18.7	1.0140	1.5
19	0825	110		90	37	10.7	1.0245	1.5
20	0805	90	35		38	12.7	1.0238	2.7
21	0620	55		95	7	15.8	1.0193	1.8
22	1050	35		70	71	17.5	1.0154	0.9
23	1100	65	25		29	18.3	1.0141	2.1
24	0530	none visible			40	17.2	1.0186	1.2
25	0507	80	130		73	10.6	1.0242	1.2
26	0525	80	135		56	10.1	1.0247	1.2
27	0515	75	20		85	17.2	1.0158	1.5
28	0515	95			46	15.9	1.0191	1.8
29	1030	75			23	10.4	1.0248	1.2
30	1125	35	75	100	45	17.1	1.0214	2.4
31	0500	85	100	90	8	17.3	1.0193	2.1

## 6 Water Levels

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Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A Leupold-Stevens digital recording float-type tide gauge is used to collect instantaneous water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 4 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 7 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

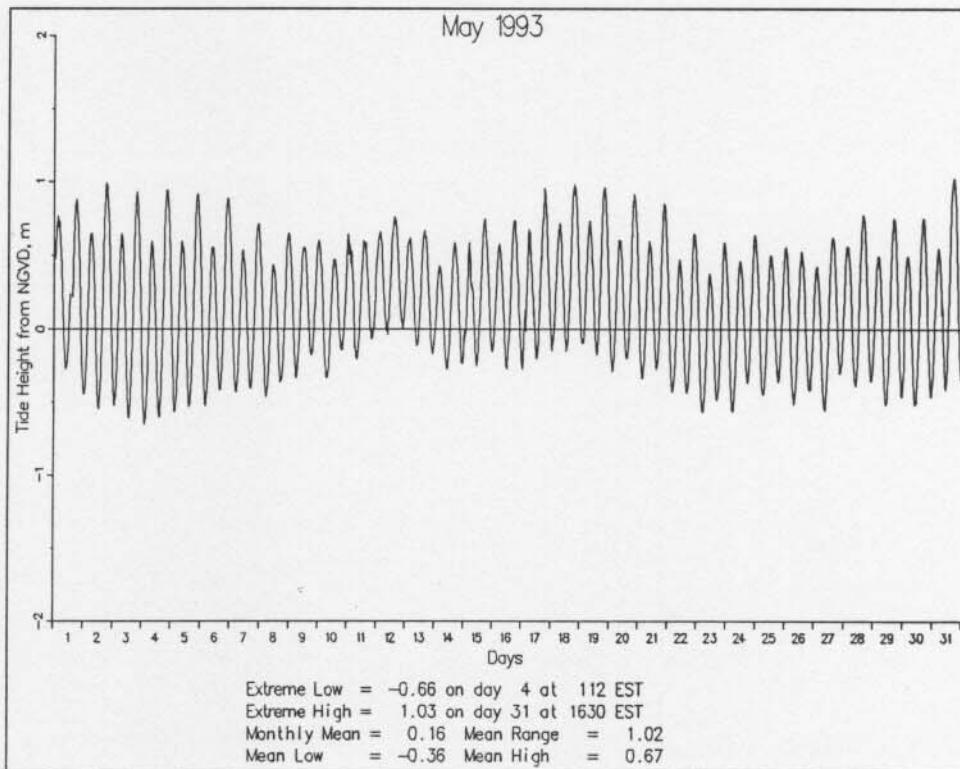


Figure 4. Water Level Time History

**Table 7**  
**Water Levels, m NGVD**

Day	May 93												
	High		Low		Mean Range		High		Low		Mean Range		
Time	m	Time	m	m	m	Day	Time	m	Time	m	m		
1	0206	0.77	0812	-0.27	0.24	1.04	16	1654	0.74	2348	-0.27	0.25	1.01
1	1226	No data for this tide cycle					17	0518	0.67	1112	-0.20	0.19	0.88
2	0448	0.65	1124	-0.55	0.08	1.19	17	1800	0.95	2354	-0.15	0.39	1.10
2	1724	0.99	0012	-0.53	0.27	1.52	18	0642	0.72	1142	-0.15	0.28	0.87
3	0606	0.65	1218	-0.61	0.02	1.26	18	1830	0.98	0106	-0.10	0.45	1.08
3	1854	0.93	0112	-0.66	0.16	1.58	19	0706	0.73	1254	-0.18	0.27	0.91
4	0654	0.60	1324	-0.60	-0.03	1.20	19	1918	0.96	0200	-0.29	0.36	1.25
4	1930	0.94	0136	-0.57	0.22	1.51	20	0712	0.60	1342	-0.20	0.18	0.80
5	0736	0.60	1336	-0.53	0.02	1.13	20	1942	0.92	0212	-0.34	0.30	1.25
5	2030	0.92	0300	-0.53	0.22	1.44	21	0824	0.59	1406	-0.27	0.15	0.87
6	0830	0.56	1436	-0.42	0.05	0.98	21	2012	0.85	0254	-0.43	0.22	1.28
6	2118	0.89	0348	-0.43	0.25	1.32	22	0906	0.47	1442	-0.43	0.00	0.90
7	0918	0.54	1542	-0.41	0.05	0.94	22	2100	0.65	0348	-0.57	0.05	1.22
7	2200	0.71	0412	-0.46	0.15	1.18	23	0948	0.37	1536	-0.49	-0.07	0.86
8	1012	0.44	1548	-0.36	0.01	0.80	23	2124	0.59	0436	-0.57	0.02	1.16
8	2242	0.65	0454	-0.34	0.17	0.99	24	1054	0.46	1700	-0.37	0.04	0.83
9	1124	0.56	0648	-0.19	0.18	0.74	24	2248	0.64	0530	-0.45	0.10	1.09
9	2318	0.60	0554	-0.34	0.16	0.94	25	1142	0.50	1754	-0.37	0.07	0.87
10	1212	0.48	0742	-0.26	0.14	0.73	25	2354	0.55	0630	-0.52	0.04	1.07
10	2342	0.64	0654	-0.21	0.20	0.85	26	1230	0.52	1918	-0.42	0.04	0.95
11	1236	0.60	0836	-0.08	0.25	0.68	27	0054	0.42	0742	-0.56	-0.05	0.98
12	0224	0.66	0812	-0.04	0.31	0.70	27	1354	0.62	1930	-0.30	0.15	0.92
12	1424	0.76	2036	0.01	0.40	0.75	28	0124	0.56	0818	-0.39	0.11	0.95
13	0248	0.62	0824	-0.12	0.27	0.73	28	1436	0.77	2100	-0.35	0.22	1.13
13	1448	0.67	2130	-0.17	0.27	0.84	29	0242	0.49	0854	-0.52	0.01	1.01
14	0324	0.43	0918	-0.27	0.08	0.70	29	1542	0.75	2148	-0.47	0.17	1.22
14	1600	0.59	2136	-0.23	0.18	0.82	30	0236	0.49	0848	-0.52	-0.01	1.01
15	0342	0.59	0942	-0.25	0.12	0.84	30	1536	0.75	2142	-0.47	0.16	1.22
15	1654	0.75	2254	-0.15	0.30	0.90	31	0354	0.55	0954	-0.41	0.09	0.96
16	0500	0.58	1100	-0.27	0.17	0.85	31	1630	1.03	2324	-0.37	0.43	1.40

## 7 Bathymetry

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A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 5 shows the last survey in April 1993 and the surveys in May 1993 on profile line 188, located 517 m south of the pier.

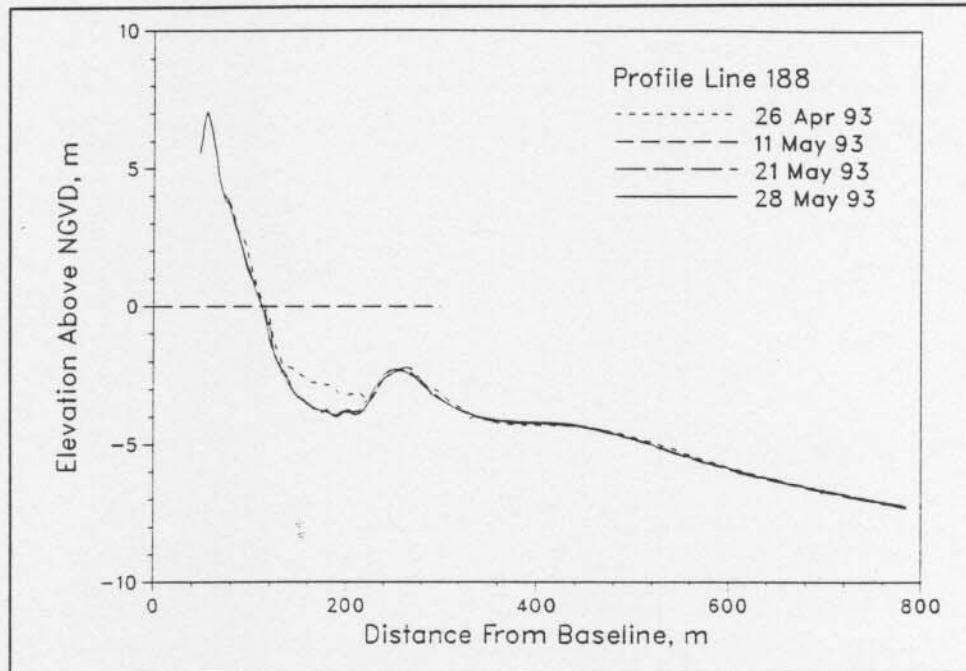


Figure 5. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 6) reflects the maximum changes that occurred on the profile during 1993. Cross-hatched areas indicate changes to the annual envelope which occurred in May.

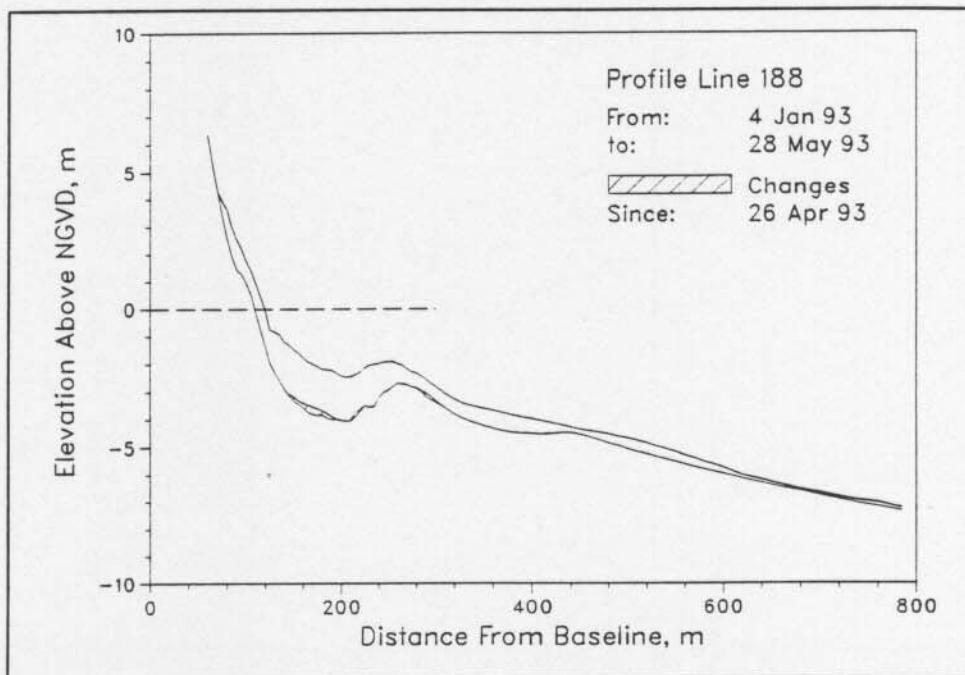


Figure 6. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 7 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 11 May. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

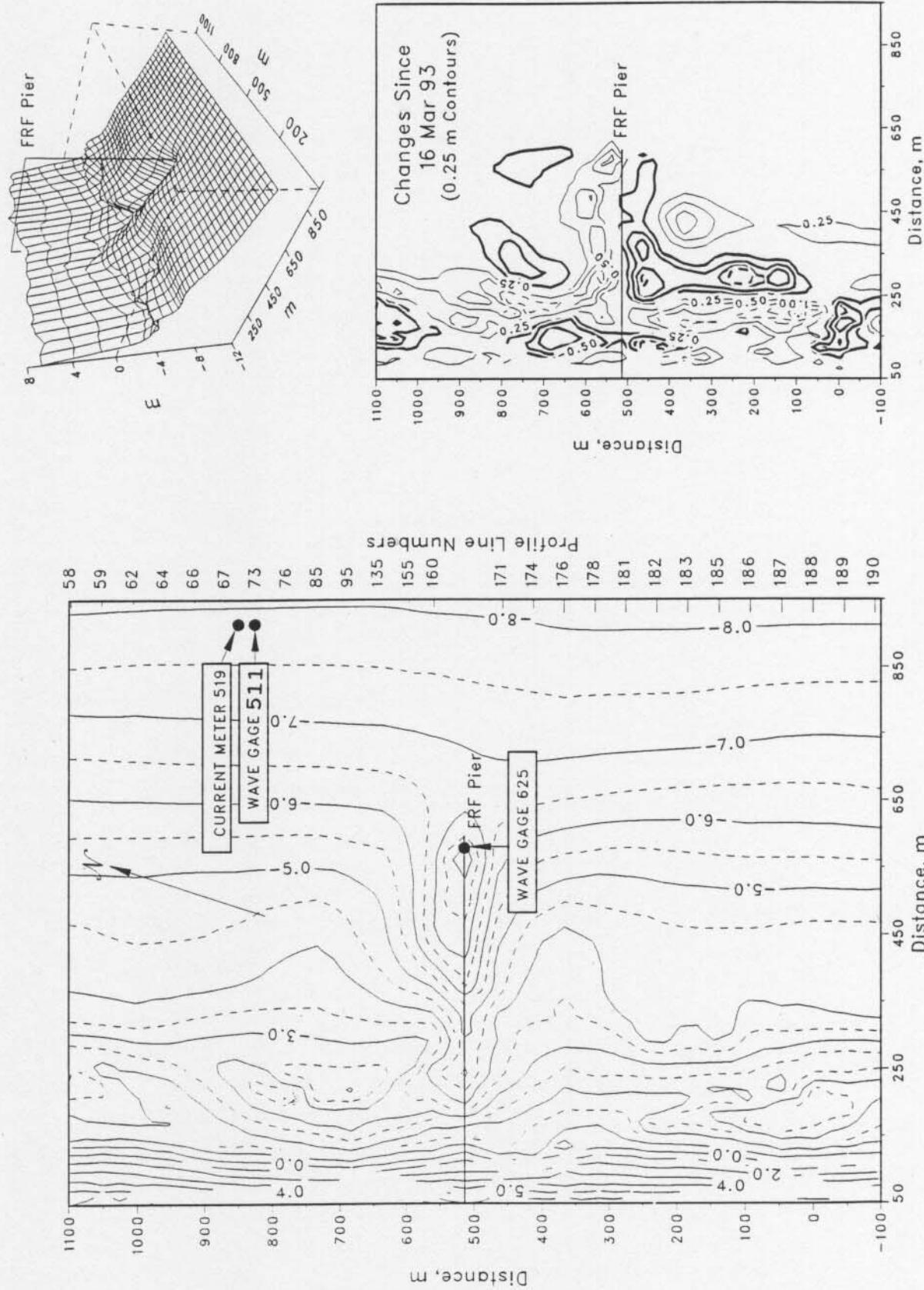


Figure 7. FRF bathymetry 11 May 93 depths relative to NGVD

### Distribution List

#### Government Agencies:

Back Bay National Wildlife Refuge	U.S. Geological Survey
USACE-OCE	U.S. Library of Congress
USACE-SAD	U.S. National Park Service
USACE-NAP	U.S. National Weather Service
USACE-SAW	U.S. Naval Academy
USACE-WES	U.S. Naval Civil Eng. Lab
NAVSAC	U.S. Naval Oceanographic Off.
NOAA/NOS/OMS	U.S. Naval Research Lab
National Marine Fisheries	

#### Colleges/Universities:

Bucknell University	Scripps Institution of Oceanography
California Inst. of Tech.	Stockton State College
Duke Marine Lab	University Calif-Berkeley
East Carolina University	University of Florida
Florida Inst. of Tech.	University of Maryland-College Park
M.I.T.	University of Maryland-Baltimore
Naval Post Graduate School	University of North Carolina
NC State University	University of N C-Seagrant Program
Old Dominion University	University of Virginia
Oregon State University	Va. Inst. of Marine Science
Prince George's College	Rutgers University

#### Others:

Allied Signal Aerospace Co.	WCTI-TV
Applied Physics Lab	MEC Systems Corporation
Cape Hatteras Nat. Seashore	Moffatt & Nichol, Eng.
Coastal and Est. Res., Inc.	N.C. Div. Coastal Management
Coastal Science & Eng., Inc.	Oregon Inlet & Waterways Commis.
Dr. Cy Galvin	Raleigh-Durham Airport
GEOMET Tech., Inc.	Mr. Rowland
Mr. Hodges	Mr. Savage
Dr. Hylton	Science Application Int'l. Corp
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Mr. Rodgers	SEASUN Power Systems

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Ministry of Works, Bahamas
Dalhousie University, Halifax Nova Scotia
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